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FEDERAL COMMUNICATIONS COMMISSION
INTERNATIONAL BUREAU

December 1, 1995

Mr. William F. Caton
Acting Secretary
Federal Communications Commission
1919 M Street, N.W., Room 222
Washington, D.C. 20554

RE: Ex Parte Communication
CC Docket 92-297

Dear Mr. Caton:

This will serve to indicate that on December 1, 1995 Tom Tycz, Harry Ng, Karl Kensinger, Jennifer Gilsenan, and Giselle Gomez of the International Bureau, Bob James of the Wireless Telecommunications Bureau, and Michael Marcus of the Office of Engineering and Technology, met with the attached list of people, to discuss interservice frequency sharing rules. The attached documents were distributed to those present.

Sincerely,

Jennifer M. Gilsenan

Jennifer M. Gilsenan

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Motorola / Texas Instruments Meeting

Dec. 1, 1995

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Bary Bertiger
Corporate Vice President

~~Assistant~~ General Manager
Satellite Communications Division

November 27, 1995

Mr. Thomas S. Tycz
Chief, Satellite and Radio Communication Division
Federal Communications Commission, International Bureau
2000 M Street, N.W., Suite 811
Washington, DC 20554

Dear Tom:

In furtherance of our meeting with the FCC staff and various LMDS interests on November 2nd, I am submitting the following:

1. Proposed rules for sharing with LMDS at 29 GHz.
2. An assessment of composite interference on the IRIDIUM" system bit error rate.
3. An analysis of the TI sharing analysis.
4. Motorola's views on the TI analysis.

As you requested in the November 2nd meeting, I am attaching a copy of proposed rules (Appendix A) for both the LMDS hubs and subscriber units operating co-frequency with the IRIDIUM satellite control links and the Gateway feeder links at 29 GHz.

You also requested an analysis on the effect of the composite interference level on our bit error rate. Table 1 shows this data.

Table 1 - Bit Error Rate vs. Interference Level

Interference Level (dBW/Hz)	Bit Error Rate	Number of bits in error in 3.2 seconds of transmission
-207.5	$1.0e^{-7}$	1
-204.5	$3.4e^{-7}$	3.4
-201.5	$5.4e^{-6}$	540
-198.5	$2.1e^{-4}$	2,100
-195.5	$4.2e^{-3}$	42,000
-192.5	$4.4e^{-2}$	440,000
-189.5	$2.8e^{-1}$	2,800,000

The link quality objective for the IRIDIUM system is a bit error rate of 1×10^{-7} when the system is fully faded. This bit error rate of 1×10^{-7} corresponds to an $e_b/(n_o+i_0)$ of 7.7 dB which includes a 2.0 dB implementation loss in the space vehicle demodulator. The interference allocation of -207.5 dBW/HZ is from all sources. The allocation for the composite LMDS interference is half this level (i.e. a level of -210.5 dBW/Hz). This is the value that was used in the 28 GHz Negotiated Rulemaking.

TI claims the composite interference level from LMDS subscribers at the IRIDIUM satellite would only be -192.0 dBW/Hz. Our assessment of the TI analysis indicates that the correct value should be -189.0 dBW/Hz. As can be seen from Table 1, interference at either of these levels, when viewed in the bit error context, will have a devastating impact on the quality and reliability of the IRIDIUM feeder links.

The following statements summarize our views on the TI sharing analysis:

1. The analysis used by TI purportedly showing that sharing of co-frequency LMDS subscribers and IRIDIUM System feeder links is seriously flawed. As Dr. Kubik stated in the November meeting, the TI analysis is in error by an order of 20 to 27 dB and this was documented in the paper we presented at the meeting.

2. Our analysis shows that even a single correctly pointed LMDS subscriber unit will exceed the interference criteria of -210.5 dBW/Hz allocated for LMDS. Our analysis also shows that interference from the sidelobes of a few correctly pointed LMDS subscriber units will exceed this interference criteria.

3. TI's sharing analysis is based upon changing the interference ground rules that were used as a basis for the 28 GHz Negotiated Rulemaking. TI's newly asserted interference criteria are so different from what was used in the Negotiated Rulemaking that they call into question previous determinations concerning the sharing of LMDS with the other FSS systems (e.g. Teledesic and Hughes). It is not fair to put this potential sharing burden solely on the IRIDIUM system without also reopening discussions as to the potential for sharing LMDS subscriber units with other services in the band.

4. TI's sharing analysis uses a portion of the IRIDIUM system propagation fade margin to combat LMDS interference. Such an approach is totally unacceptable to Motorola. The loss of propagation fade margin to an IRIDIUM Gateway causes an unacceptable increase in the outage time of the links, which in the case of the dual channel Gateways, are carrying up to 1920 channels of traffic simultaneously. Operation at high levels of interference (-189.0 dBW/Hz) would increase outages from 8.8 to 28.4 hours/year, an increase of 223% for our dual channel, dual diversity stations. The 26 dB fade margin for dual channel stations covers rain fades, atmospheric attenuation, cloud attenuation and scintillation effects. All of these sources of signal fading are greatest at the lower elevation angles where the LMDS systems will cause the most interference to the IRIDIUM satellites. As we have previously stated, the IRIDIUM system must be able to operate down to an elevation of 5 degrees to insure adequate coverage for our feeder links.

5. TI's proposed rules would allow LMDS interference to be considerably above the noise of the IRIDIUM satellite receivers. This would force the feeder link stations to operate at a power level considerably above the minimum required for fade compensation. The IRIDIUM system uses uplink power control in a manner consistent with results of WRC-95 and with existing FCC Rule 25.204(c) which state the following respectively:

   "Feeder links of non-GSO MSS networks and GSO FSS networks operating in the band 29.1-29.4 GHz (Earth to space) shall employ uplink adaptive power control or other methods of fade compensation, such that they meet the desired link performance while reducing the level of mutual interference between both networks ....".
   Footnote S5.535B

   "For operation at frequencies above 10 GHz, earth stations operators may exceed the uplink e.i.r.p. and e.i.r.p. density limits specified in the station authorization under the conditions of uplink fading due to precipitation by an amount not to exceed 1 dB above the actual amount of monitored excess attenuation over clear sky propagation conditions. The e.i.r.p. levels shall be returned to normal as soon as the attenuating weather pattern subsides. The maximum power level for power control purposes shall be coordinated between and among adjacent satellite operators."
   C.F.R Section 25.204(c)

   It should be noted that these requirements for power control are to assist in sharing with GSO systems operating in the band. However, noise allocation to or from such sources, or the impact on the IRIDIUM system sharing with the GSO systems is not included as part of the TI analysis.

6. TI is placing the entire burden of sharing on the IRIDIUM system. TI can take steps to reduce the radiated power from its subscribers by increasing the gain of its hub receive antennas from 12 dB to a level that would allow sharing. As stated in the November meeting by Doug Lockie of Endgate Technologies, a 38 dB gain antenna can be incorporated into the Hubs. This would reduce the level of subscriber transmitter power so that sharing would be possible.

7. TI was absolutely wrong when it claimed that Motorola did not try to work out LMDS/IRIDIUM sharing in the Negotiated Rulemaking. As the FCC is well aware, Motorola tried very hard to come up with equitable sharing rules and was the only satellite company that reached agreement with the LMDS interests (including TI).

8. TI also claimed that they signed the LMDS/Motorola sharing agreement subject to certain conditions that have not been met. We can find no such conditions in the sharing agreement or appended to TI's signature.

9. TI continues to include Cellularvision in its analysis, but Cellularvision stated in the November meeting that it stands by the sharing analysis which was mutually agreed upon in the Negotiated Rulemaking (i.e., no return links in the MSS feeder link band).

In summary, for the reasons stated above, Motorola is opposed to co-frequency operation of LMDS Subscriber-to-Hub links with the IRIDIUM feeder links under the conditions proposed by TI. The proposed TI sharing criteria pose an unacceptable risk to the successful operation of the IRIDIUM system. The IRIDIUM system's feeder links support the satellite constellation command and control communication links as well as the Gateway communication links. It is very important to the financial success of the IRIDIUM system that these links provide continuous high quality communication.

These ad-hoc discussions seriously undermine the results of the Negotiated Rulemaking. It does not make any sense for parties like Motorola to try to negotiate tightly crafted sharing rules in a Negotiated Rulemaking if these agreements are to be voided after the fact by parties to the earlier agreement. Absent an unexpected breakthrough in these discussions, Motorola urges the Commission to adopt its proposal not to allow subscriber links to share the MSS feeder link spectrum.

Regards,

MOTOROLA

Bary Bertiger

Bary Bertiger
Corporate Vice President and General Manager
Satellite Communications Division

Attachments

cc: (via hand delivery)
Harry Ng
Karl Kensinger
Robert James
Susan Magnotti
Michael Marcus
Joslyn Read
Jennifer Gilsenan

cc: (via fax)
Gene Robinson
Doug Gray
Eric Barnhart
Doug Lockie
David Keir
Paul Misener

IRIDIUM is a registered trademark and service mark of Iridium, Inc.

APPENDIX B

Proposed Rule Amendments to 47 C.F.R. Part 21 and Part 25 of the Commission's rules

1. Section 21.2 is proposed to be amended by adding new paragraphs, in alphabetical order, to read as follows:

*****

Local Multipoint Distribution Service Hub Station. A fixed point-to-multipoint radio station in a Local Multipoint Distribution Service System that provides one-way or two-way communication with Local Multipoint Distribution Service Subscriber Stations.

*****

Local Multipoint Distribution Service System. A fixed point to-multipoint radio system consisting of Local Multipoint Distribution Service Hub Stations and their associated Local Multipoint Distribution Service Subscriber Stations.

*****

Local Multipoint Distribution Service Subscriber Station. Any one of the fixed microwave radio stations located at users' premises, lying within the coverage area of a Local Multipoint Distribution Service Hub Station, capable of receiving one-way communications from or providing two-way communications with the Local Multipoint Distribution Service Hub Station.

*****

Local Multipoint Distribution Service Backbone Link. A point-to-point radio service link in a Local Multipoint Distribution Service System that is used to interconnect Local Multipoint Distribution Service Hub Stations with each other or with the public switched telephone network.

2. Section 21.107 is amended by revising paragraph (b) by deleting the Table entry for the frequency band 27,500 MHz to 29,500 MHz line in the Table, and adding a new line to the Table to read as follows:

§ 21.107 Transmitter power.

*****

(b) ***

Frequency Band (MHz)	Fixed (W)	Mobile (W)	Fixed (dBW)	Mobile (dBW)
*****	*****	*****	*****	*****
27,500 MHz to 28,350 MHz 29,100 MHz to 29,250 MHz			-52 dBW/Hz [5]	

[5] This value is based on the value in §§ 21.1018-21.1021.

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3. Amend proposed rule section 21.1002 by adding new subsection (c) as follows:

§ 21.1002 **Frequencies**

(c) Special requirements for operations in the band 29.1-29.25 GHz

(1)(i) LMDS receive stations operating on frequencies in the 29.1- 29.25 GHz band within a radius of 75 nautical miles of the geographic coordinates provided by a non-GSO MSS licensee pursuant to subsections (c)(2) or (c)(3)(i) (the "feeder link earth station complex protection zone") shall accept any interference caused to them by such earth station complexes and shall not claim protection from such earth station complexes.

(ii) LMDS licensees operating on frequencies in the 29.1-29.25 GHz band outside a feeder link earth station complex protection zone shall cooperate fully and make reasonable efforts to resolve technical problems with the non-GSO MSS licensee to the extent that transmissions from the non-GSO MSS operator's feeder link earth station complex interfere with an LMDS receive station.

(2) At least 45 days prior to the commencement of LMDS auctions, feeder link earth station complexes shall be specified by a set of geographic coordinates in accordance with the following requirements: no feeder link earth station complex may be located in the top eight (8) metropolitan statistical areas ("MSAs"), ranked by population, as defined by the Office of Management and Budget as of June 1993, using estimated populations as of December 1992; two (2) complexes may be located in MSAs 9 through 25, one of which must be Phoenix, AZ (for a complex at Chandler, AZ); one (1) complex may be located in MSAs 26 to 50; three (3) complexes may be located in MSAs 51 to 100, one of which must be Honolulu, Hawaii (for a complex at Waimea); and the two (2) remaining complexes must be located at least 75 nautical miles from the borders of the 100 largest MSAs or in any MSA not included in the 100 largest MSAs. Any location allotted for one range of MSAs may be taken from an MSA below that range.

(3)(i) Any non-GSO MSS licensee may at any time specify sets of geographic coordinates for feeder link earth station complexes with each earth station contained therein to be located at least 75 nautical miles from the borders of the 100 largest MSAs.

(ii) For purposes of subsection (c)(3)(i), non-GSO MSS feeder link earth station complexes shall be entitled to accommodation only if the affected non-GSO MSS licensee reapplies to the Commission for a feeder link earth station complex or certifies to the Commission within sixty days of receiving a copy of an LMDS application that it intends to file an application for a feeder link earth station complex within six months of the date of receipt of the LMDS application.

(iii) If said non-GSO MSS licensee application is filed later than six months after certification to the Commission, the LMDS and non-GSO MSS entities shall still cooperate fully and make reasonable efforts to resolve technical problems, but the LMDS licensee shall not be obligated to re-engineer its proposal or make changes to its system.

or subscriber terminals

(4) LMDS licensees or applicants proposing to operate hub stations on frequencies in the 29.1-29.25 GHz band at locations outside of the 100 largest MSAs or within a distance of 150 nautical miles from a set of geographic coordinates specified under subsection (c)(2) or (c)(3)(i) shall serve copies of their applications on all non-GSO MSS applicants, permittees or licensees meeting the criteria

specified in § 25.257(a). Non-GSO MSS licensees or applicants shall serve copies of their feeder link earth station applications on any LMDS applicant or licensee within a distance of 150 nautical miles from the geographic coordinates that it specified under subsection (c)(2) or (c)(3)(i). Any necessary coordination shall commence upon notification by the party receiving an application to the party who filed the application. The results of any such coordination shall be reported to the Commission within sixty days. The non-GSO MSS earth station licensee shall also provide all such LMDS licensees with a copy of its channel plan.

4. A new Section 21.1018 is proposed to read as follows:

§ 21.1018 LMDS Single Station EIRP Limit.

Point-to-point stations in the 29.1-29.5 GHz band for the LMDS backbone between LMDS hubs shall be limited to a maximum allowable EIRP density per carrier of 23 dBW/MHz in any one megahertz in clear air, and may exceed this limit by employment of adaptive power control in cases where link propagation attenuation exceeds the clear air value due to precipitation and only to the extent that the link is impaired.

5. A new Section 21.1019 is proposed to read as follows:

§ 21.1019. LMDS Subscriber Transmissions.

~~LMDS licensees shall not operate transmitters from subscriber locations in the 29.1-29.25 GHz band.~~

SEE ATTACHED INSERT

6. A new Section 21.1020 is proposed to read as follows:

or Subscriber

§ 21.1020 Hub Transmitter EIRP Spectral Area Density Limit.

or subscriber-to-hub

or subscriber

(a) LMDS applicants shall demonstrate that, under clear air operating conditions, the maximum aggregate of LMDS transmitting hub stations in a Basic Trading Area in the 29.1-29.25 GHz band will not transmit a co-frequency hub-to-subscriber EIRP spectral area density in any azimuthal direction in excess of X dBW/(MHz-km^2) when averaged over any 4.375 MHz band, where X is defined in Table 1. Individual hub stations may exceed their clear air EIRPs by employment of adaptive power control in cases where link propagation attenuation exceeds the clear air value and only to the extent that the link is impaired.

(b) The EIRP aggregate spectral area density is calculated as follows:

$$10\log\left[1/A \sum_{i=1}^{N} p_i g_i\right] dBW/MHz\text{-}km^2$$

where:

or subscribers

N = number of co-frequency hubs in BTA

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or subscriber

or subscriber

A = Area of BTA in km^2

p_i = spectral power density into antenna of i-th hub (in W/MHz)

g_i = gain of i-th hub antenna at zero degree elevation angle

Each p_i and g_i are in the same 1 MHz

(c) The climate zones in Table 1 are defined for different geographic locations within the US as shown in Appendix 28 of the ITU Radio Regulations and Section 25.254 of the Commission's Rules.

Table 1*

Climate Zone	EIRP Spectral Density (Clear Air) (dbW/MHz-km^2)**
1	-23
2	-25
3,4,5	-26

* LMDS system licensees in two or more BTAs may individually or collectively deviate from the spectral area density computed above by averaging the power over any 200 km by 400 km area, provided that the aggregate interference to the satellite receiver is no greater than if the spectral area density were as specified in Table 1. A showing to the Commission comparing both methods of computation is required and copies shall be served on any affected non-GSO MSS providers.

** See Section 21.1007(c)(i) for the population density of the BTA

7. A new rule Section 21.1021 is proposed to read as follows:

or Subscriber

§ 21.1021 Hub Transmitter EIRP Spectral Area Density Limit at Elevation Angles Above the Horizon.

or subscriber or subscriber-to-hub

(a) LMDS applicants shall demonstrate that, under clear air operating conditions, the maximum aggregate of LMDS transmitting hub stations in a Basic Trading Area in the 29.1-29.25 GHz band will not transmit a co-frequency hub-to-subscriber EIRP spectral area density in any azimuthal direction in excess of X dBW/(MHz-km^2) when averaged over any 5.375 MHz band where X is defined in Table 2. Individual hub ~~stations~~ may exceed their clear air EIRPs by employment of adaptive power control in cases where link propagation attenuation exceeds the clear air value and only to the extent that the link is impaired. 4

or subscriber

(b) The EIRP aggregate spectral area density is calculated as follows:

$$10\log\left[1/A \sum_{i=1}^{N} \mathrm{EIRP}(a_i)\right] \; dBW/MHz\text{-}km^2$$

where:

or subscribers

N = number of co-frequency hubs in BTA

A= Area of BTA in km^2

EIRP(a_i) = equivalent isotropic radiated spectral power density of the i-th hub (in W/MHz) at elevation angle a

Table 2*

Elevation Angle (a)	Relative EIRP Density (dBW/MHz-km^2)
$0^\circ \le a \le 4.0^\circ$	EIRP(a) = EIRP(0°) + 20 log ($\sin\Pi x$)($1/\Pi x$) where $x = (a + 1)/7.5^\circ$
$4.0 < a \le 7.7^\circ$	EIRP(a) = EIRP(0°) - 3.85a + 7.7
$a > 7.7^\circ$	EIRP(a) = EIRP(0°) - 22

and subscriber

where a is the angle in degrees of elevation above horizon. EIRP(0°) is the hub EIRP area density at the horizon used in Section 21.1020. The nominal antenna pattern will be used for elevation angles between 0° and 8°, and average levels will be used for angles beyond 8°, where average levels will be calculated by sampling the antenna patterns in each 1° interval between 8° and 90°, dividing by 83.

* LMDS system licensees in two or more BTAs may individually or collectively deviate from the spectral area density computed above by averaging the power over any 200 km by 400 km area, provided that the aggregate interference to the satellite receiver is no greater than if the spectral area density were as specified in Table 1. A showing to the Commission comparing both methods of computation is required and copies shall be served on any affected non-GSO MSS providers.

8. A new rule section 21.1022 as follows:

§ 21.1022 Power Reduction Techniques.

and subscriber

LMDS hub transmitters shall employ methods to reduce average power levels received by non-GSO MSS satellite receivers, to the extent necessary to comply with Sections 21.1020 and 21.1021, by employing the methods set forth below:

and subscriber

(a) <u>Alternate Polarizations</u>. LMDS hub transmitters in the LMDS service area may employ both vertical and horizontal linear polarizations such that 50 percent (plus or minus 10

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percent) of the hub transmitters shall employ vertical polarization and 50 percent (plus or minus 10 percent) shall employ horizontal polarization.

subscriber　　　　　　　　　　　　subscriber

(b) <u>Frequency Interleaving.</u> LMDS hub transmitters in the LMDS service area may employ frequency interleaving such that 50 percent (plus or minus 10 percent) of the hub transmitters shall employ channel center frequencies which are different by one-half the channel bandwidth of the other 50 percent (plus or minus 10 percent) of the hub transmitters.

(c) <u>Alternative Methods</u>. As alternatives to (a) and (b) above, LMDS operators may employ such other methods as may be shown to achieve equivalent reductions in average power density received by non-GSO MSS satellite receivers.

Proposed Rule Amendments to 47 C.F.R. Part 25 of the Commission's Rules

Part 25 of the Commission's Rules and Regulations (Chapter I of Title 47 of the Code of Federal Regulations) is proposed to be amended as follows:

1. A new Section 25.257 is proposed to read as follows:

§ Special requirements for operations in the band 29.1-29.25 GHz

(a) Special requirements for operations in the band 29.1-29.25 GHz

(1) Non-geostationary mobile satellite service (non-GSO MSS) operators shall use the 29.1-29.25 GHz band for Earth-to-space transmissions from feeder link earth station complexes. For purposes of this subsection, a "feeder link earth station complex" may include up to three (3) earth station groups, with each earth station group having up to four (4) antennas, located within a radius of 75 nautical miles of a given set of geographic coordinates provided by a non-GSO MSS operator pursuant to ~~subsections (c)(5) or (c)(6)(i).~~
§§ 21.1002(c)(2) or (c)(3)(i).

(2) A maximum of eight (8) feeder link earth station complexes in the contiguous United States, Alaska, and Hawaii may be operated concurrently in the band 29.1-29.25 GHz.

non-　　　　mobile

(b) Coordination of LMDS systems and geostationary ~~fixed~~ satellite systems in the band 29.1-29.25 must be done in accordance with the technical standards of ~~§§ 21.1018-21.1024.~~
§§ 21.1002(c) and
21.1018 - 21.1024

INSERT

21.1019 LMDS Subscriber Transmissions.

LMDS licensees wishing to operate transmitters from subscriber locations in the 29.1-29.25 GHz band shall be subject to the following additional requirements:

(a) Subscriber Transmitter EIRP Limit: Subscriber-to-hub transmissions shall be limited to a maximum allowable EIRP per carrier of 0 dBWi/MHz in any one megahertz in clear air, and may exceed this limit by employment of adaptive power control in cases where link propagation attenuation exceeds the clear air value and only to the extent that the link is impaired.

(b) Hub-to-Subscriber transmissions on these frequencies shall be prohibited.

(c) Subscriber equipment must be implemented with transmitter interlocks in such a manner so as to require that a signal be received from the hub before enabling the subscriber return link transmit function. In addition, the antenna mounting structure must be vertical within 5 degrees.

Texas Instruments Incorporated

TEXAS INSTRUMENTS

Post Office Box 650311
Dallas, Texas 75265
7839 Churchill Way
Dallas, Texas 75251

November 28, 1995

Mr. John Knudsen
Motorola Satellite Communications
2501 South Price Road
Chandler, Arizona 85248

Dear John,

The enclosed material, which includes previous analyses and new studies conducted by the various LMDS participants, continues to point out the feasibility of the LMDS CPE subscriber transceiver return links and the Iridium MSS/FSS feeder links to operate as co-primary and share the 29.1 to 29.25 GHz spectrum.

The statistical analysis and the direct beam analysis of 12 September 1995 (attachment B) is supported by the proposed rules (attachment C) and attachments D through K. The population density and gateway parameters show acceptable bit error rates for the Iridium gateway link. An examination of the Iridium satellite orbits (attachment E) shows that for the mid-CONUS gateway the minimum elevation angle at which the satellite is visible is 11.9 degrees (not 5 degrees) and provides 4 dB of system power control margin to allow the Iridium feeder link margin to be maintained without degradation to the link's bit error rate. The power spectral density is shown by attachment F to be only dependent on the maximum EIRP at the periphery of the cell and not on the LMDS coverage radius. Also, attachment G shows that the look-up angle for CPE's is less than 5 degrees for a 30 meter hub antenna height, the maximum proposed by any of the LMDS operators in attachment B. Also, the CPE look-up angle is less than 10 degrees for hub to CPE distances of 2 KM and greater with 300 meter differential antenna heights. The slant range between the feeder link gateway and the satellite and the differential signal levels (attachment H) shows an additional 1.73 dB increase in the gateway signal with satellite elevation angles of 11 degrees. This increase signal is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference. In fact, it is sufficient to offset a 10 dB interference increase as shown in attachment I.

The equivalent CPE sidelobe energy is shown in attachment J to offset the Iridium power control signal reduction with more than a 10 dB margin, (-21.5 dB for CPE's versus -10 dB for the MSS/FSS feeder link). Thus, there is no short range (90 degree elevation, 780 KM) incompatibility between the LMDS return links and the gateway satellite. Main beam coupling at this minimum range only results in 0.2 dB signal degradation which is easily overcome with an accordingly small increase in gateway transmit power.

Attachment K is an analysis of CPE transceiver fit to the proposed rules 21.1020 and 21.1021 of the Third NPRM for 28 GHz. This analysis shows that at 7.5 degrees elevation the power spectral area density is 2 dB to 9 dB below the required limit proposed by the Third NPRM for LMDS hubs. At 90 degrees elevation the power spectral area density is 6 dB to 15 dB below the required limit. Thus, the CPEs are capable of sharing the 29.1 to 29.25 GHz spectrum the same as LMDS hubs.

In summary,

- Acceptable bit error rates are achievable while sharing.(Attachments B-D)
- Minimum elevation for the mid-CONUS gateway is 11.9 degrees resulting in a 4 dB system power control margin. (Attachment E)
- Power spectral density is not dependent on LMDS cell radius. (Attachment F)
- Look-up angle for CPEs are typically not greater than 5 degrees. (Attachment G)
- Maximum slant range to the satellite is less at the 11 degree elevation
  - -results in 1.73 dB increase in the gateway signal, which is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference.
  - -sufficient margin exist to offset 10 dB interference increase. (Attachment H and I)
- CPE aggregate sidelobe power decreases 11.5 dB more than the satellite power control at short range, 90 degree elevation. (Attachment J)
- CPE transceivers can fit the Proposed rules, 21.1020 and 21.1021 of the Third NPRM suggested for LMDS hubs. (Attachment K)

Thus, the analyses presented demonstrate the feasibility of the Iridium MSS/FSS feeder links to co-share the 29.1 to 29.25 GHz with CPE return links using the proposed rules of attachment C or the proposed hub EIRP spectral area density rules, 21.1020 and 21.1021, of the Third NPRM.

Regards,

Gene Robinson

Gene Robinson
Senior Fellow, Texas Instruments

Attachments A-K
Distribution

ATTACHMENTS
28 November 1995

LMDS SUBSCRIBER AND IRIDIUM CO-PRIMARY SHARING OF THE 29.1-29.25 GHZ BAND

ATTACHMENTS
28 November 1995

LMDS SUBSCRIBER AND IRIDIUM CO-PRIMARY SHARING OF THE 29.1-29.25 GHZ BAND

A. INTRODUCTION
-Extensive analysis shows LMDS subscriber return links and Iridium MSS/FSS feeder links can share the 29.1-29.25 GHz band.

B. LOCAL MULTIPOINT DISTRIBUTION SERVICE CUSTOMER PREMISE EQUIPMENT TRANSMISSION AND IRIDIUM SATELLITE RECEIVER COMPATIBILITY ANALYSIS, SEPTEMBER 12, 1995.
-LMDS subscriber CPE parameters and Iridium feeder links are shown to yield acceptable C/I ratios using both the statistical analysis program that models the LMDS CPE deployment and the direct beam interaction analysis.

C. PROPOSED RULES FOR LMDS SUBSCRIBER TRANSCEIVERS IN THE 29.1-29.25 GHZ BAND.
-Proposed rules for maximum EIRP, (20 dBW/MHz, clear air with power control and 14 dBW/MHz without power control), and antenna mask allows for co-primary operation.

D. POPULATION DENSITY AND GATEWAY PARAMETERS BIT ERROR RATE ANALYSIS.
-Shows Motorola's N/I and C/I ratio levels along with acceptable bit error rates for the Iridium gateway link.

E. AN EXAMINATION OF IRIDIUM ORBITS AND GATEWAY ELEVATION ANGLE-IMPACT ON SYSTEM AVAILABILITY IN THE PRESENCE OF LMDS SUBSCRIBER TRANSMITTERS, NOVEMBER 17, 1995. Eric Barnhart, CellularVision.
-Minimum elevation angle for mid-CONUS (40 degrees North Latitude) is 11.9 degrees and produces 4 dB system power margin available to allow Motorola to maintain their desired satellite receiver operating point.

F. TOTAL POWER SPECTRAL DENSITY DEPENDENCY, OCTOBER 29, 1995. Doug Gray, Hewlett-Packard.
-Total power spectral density is dependent only on maximum EIRP at the cell periphery.

G. LOOK-UP ANGLE VERSUS HUB ANTENNA HEIGHT, OCTOBER 29, 1995. Doug Gray, Hewlett-Packard.
-Subscriber look-up angle is less than 10 degrees for ranges greater than 2 KM (300 meter hub antenna height) and less than 5 degrees for ranges greater than 100 meters, (30 meter hub antenna height).

H. SLANT RANGE TO SATELLITE AND SIGNAL LEVEL VERSUS ELEVATION ANGLE. Leland Langston, Texas Instruments.
-Elevation angle of 11 degrees, (Iridium CONUS elevation angle minimum), versus 5 degrees produces 1.73 dB increase in gateway signal level due to decreased range and space loss.

I. EFFECTS OF 5 PERCENT INTERFERENCE ALLOCATION. Bill Myers, Texas Instruments
-An interference of -210 dBW/Hz (5 percent interference budget) only represents 0.2 dB change of the system noise temperature, an interference of -207 dBW/Hz, (10 percent interference budget) results in 0.4 dB thermal noise increase. An interference of -200 dBW/Hz (10 dB increase) results in 1.7 dB power change which can be easily compensated by the system margin due to reduced range (11 degree minimum elevation angle) or by increasing the gateway power by 1.7 dB.

J. EFFECT OF SATELLITE POWER CONTROL AT MINIMUM RANGE. Bill Myers, Texas Instruments
-The aggregate sidelobe power from CPE return link transmissions will produce signal reductions much greater than the satellite link power control reductions. For main beam coupling at minimum range (90 degree elevation) a CPE operating at the maximum proposed rule power will result in only 0.2 dB degradation.

K. ANALYSIS OF CPE TRANSCEIVERS SHOWS FIT TO THE PROPOSED RULES 21.1020 AND 21.1021 PER THE THIRD NPRM FOR 28 GHZ, NOVEMBER 14, 1995. Doug Gray, Hewlett-Packard.
-At 7.5 degrees elevation, the aggregate of the LMDS CPEs power spectral area density (PSAD) is 2 dB to 9 dB below the required limit proposed for hubs.
-At 90 degrees elevation, the PSAD is 6 dB to 15 dB below the required limit.

INTRODUCTION

EXTENSIVE ANALYSES SHOW LMDS SUBSCRIBER RETURN LINKS AND IRIDIUM MSS/FSS FEEDER LINKS CAN SHARE THE 29.1-29.25 GHZ BAND.

The following attachments are the results of studies and analyses conducted by the LMDS proponents, CellularVision, Endgate Technology, Hewlett-Packard and Texas Instruments. The following is a summary of the conclusions reached by the LMDS proponents.

- Acceptable C/I ratios and bit error rates are achievable while sharing. (Attachments B-D)

- Minimum elevation for the mid-CONUS gateway is 11.9 degrees resulting in a 4 dB system power control margin. (Attachment E)

- Power spectral density is not dependent on LMDS cell radius. (Attachment F)

- Look-up angle for CPEs are typically not greater than 5 degrees. (Attachment G)

- Maximum slant range to the satellite is less at the 11 degree elevation angle,
  - -results in 1.73 dB increase in the gateway signal, which is more than adequate to offset the 0.2 dB or 0.4 dB produced by either 5 or 10 percent interference.
  - -sufficient margin exist to offset 10 dB interference increase.
  - (Attachments H and I)

- CPE aggregate sidelobe power decreases 11.5 dB more than the satellite power control at short range, 90 degree elevation. (Attachment J)

- CPE transceivers can fit the proposed rules of the Third NPRM suggested for LMDS hubs, 21.1020 and 21.1021. (Attachment K)

The analyses presented demonstrate the feasibility of the Iridium MSS/FSS feeder links to co-share the 29.1 to 29.25 GHz with CPE return links using the proposed rules of attachment C or the hub EIRP spectral area density rules, 21.1020 and 21.1021, of the Third NPRM. The proposed rules of attachment C is recommended due to the simplicity of only having to specify the maximum EIRP and antenna mask.

LOCAL MULTIPOINT DISTRIBUTION SERVICE
CUSTOMER PREMISE EQUIPMENT TRANSMISSION
AND
IRIDIUM SATELLITE RECEIVER
COMPATIBILITY
ANALYSIS

SEPTEMBER 12, 1995

INTRODUCTION

Local Multipoint Distribution Service proponents met September 6-7, 1995, to conduct analysis to determine the feasibility of the various LMDS customer premise equipment (CPE) to use the 29.1 to 29.25 GHz band as the return link frequency to the LMDS hubs and demonstrate compatibility with the Iridium satellite receiver operating in this band. The typical CPE parameters were determined for four proposed LMDS systems from CellularVision, Endgate Technology, Hewlett Packard and Texas Instruments. These systems all make use of narrow beam antennas (2.5 to 4 degree beamwidth), return link power control to adjust the transmit power for rain attenuation and/or range (0.1 km to 2.0-5 km) from the CPE to the system hub and low EIRP density at maximum range(-44.6 dBW to -52 dBW). These parameters were then used in a statistical analysis derived from the program generated by the FCC during the Negotiated Rule Making Committee for 28 GHz in 1994 and in a direct beam interaction analysis. These analyses are presented in the following sections of this report.

SUMMARY OF RESULTS

The results of the analysis using a statistical approach to CPE distribution and transmission shows that the Iridium receiver carrier to interference ratio (C/I) requirement of 20.9 dB can be met with positive margin. In addition the direct beam analysis shows that the power spectral density of -26 dBW/MHz-km^2 can be met by the various LMDS CPE return links. Thus, the LMDS CPEs are capable of using the 29.1 GHz to 29.25 GHz band for return links without harmful interference to the Iridium satellite receiver. Table one is a summary of the C/I ratios provided by each of the LMDS systems and Table two provides a summary of the power spectral density for dense and sparse populated LMDS systems.

Table One: C/I Ratio Analysis Summary

System	Total C/I	Main Beam C/I
CellularVision	36.7	37.1
Endgate Technology	27.6	28.1
Hewlett Packard	41.9	43.1
Texas Instruments	35.4	36.0

Table Two: Power Density Summary

System	200 X 400 km, dBW/MHz-km^2	2000 X 400 km, dBW/MHz-km^2
CellularVision	-42.65	-46.65
Endgate Technology	-26.2	-30.2
Hewlett Packard	-34.56	-38.56
Texas Instruments	-39.67	-43.67

STATISTICAL ANALYSIS

Overview

The aggregate power density from LMDS subscriber transmissions directed toward the Iridium satellite vehicle is calculated for four LMDS systems, Texas Instruments, Hewlett Packard, Endgate Technology and CellularVision. The aggregate power density is compared to the satellite feeder power density to provide a C/I ratio. The satellite C/I for each of 4 LMDS system ranges from 27.6 to 41.9 dB with a desired C/I of 20.9 dB.

System Parameters

The satellite parameters used as inputs to the analysis program are as follows.

SV altitude=780.0 Km.
SV half power beamwidth (HPBW) =5.0 degrees
SV elevation angle to the edge of the HPBW = 7.5 degrees
SV feeder EIRP density = -21.1 dBW/Hz
SV antenna pattern for Iridium

LMDS system parameters that were used for the four different LMDS systems in the analysis program are listed below.

Table Three: Typical LMDS System Parameters

Parameter	TI	HP	EG	CV
Transmitter Power per RF channel (dBW)	-17	-19.6	-13	-23
Modulation Type	QPSK	QPSK	4FSK	QPSK
Bandwidth of RF channel (MHz)	2.5	1.0	24	1.0
Antenna Gain (dBi)	34	35	39	31
EIRP density (dBW/Hz)	-47	-44.6	-47.8	-52
Minimum hub-CPE range (Km)	0.1	0.1	0.1	0.1
Maximum hub-CPE range (Km)	5	2	2.2	5
Tower height (meters)	30	15	20	30
Hub spacing in HPBW (Km)	17	17	17	17
Hub spacing out of HPBW (Km)	68	68	68	68
Maximum look angle for 50% blocking (Deg)	5	5	5	5

CPE Antenna pattern envelope is specific for each LMDS supplier
(Frequency reuse is included in the hub spacing density for a reuse factor of 4)

As noted above, LMDS system specific parameters are included. A common hub spacing is used for each LMDS system. This is equivalent to CPE spacing for simultaneous transmissions based on a frequency reuse factor of 4. Adjustments are made in the results for variations to these parameters for each LMDS system.

Analysis Results

Outputs resulting from the program are listed below. Adjustments are made for different frequency reuse and hub densities for each LMDS system. The number of simultaneous hub receiving frequencies is equivalent to the number of CPEs transmitting simultaneously.

Table Four: Statistical Analysis Results

Data Output and Adjustments	TI	HP	EG	CV
CPEs in SV HPBW (frequency reuse 4x)	896	896	896	896
CPEs outside the SV HPBW	3940	3940	3940	3940
C/I for CPEs within the SV HPBW (dB)	36.0	41.4	35.1	37.1
C/I for all CPEs as an aggregate (dB)	35.4	40.2	34.6	36.7
Frequency reuse adjustment (dB)	-	-	-7.0 (4/20)	-
Concentration factor (dB)		1.7 (6/4)		
Resulting Total Aggregate C/I (dB)	35.4	41.9	27.6	36.7

Adjustments for frequency reuse and concentration factors effect the number of CPEs transmitting in the calculation of density and therefore are converted to a dB value. The dB value is used to adjust the program results. HP plans on a circuit concentration of 6x which would reduce the number of hubs. Endgate plans a frequency reuse factor of 20 rather than a value of 4 that was used in calculations. It should be noted that the hub spacing derived from the population density is valid for the Endgate Technology deployment which is based primarily on business applications. The resultant C/I ratio is conservative since the hub densities should be based on business distributions instead of general population distributions.

With worst case population density, worst case subscriber density area, LMDS suitability factor of 100% and fully loaded busy hour circuits, this analysis indicates the lowest LMDS supplier aggregate C/I created by subscriber transmissions is within the required Iridium C/I limit.

DIRECT BEAM INTERACTION

The statistical analysis approach presented above provides a snapshot of the total interference into the Iridium satellite by typical LMDS CPEs for four different LMDS systems. It includes interference from CPE antenna side lobes and possibly interference from main beam interaction between the CPE antennas and the satellite. However it is a statistical model and as such does not provide an indication of what the interference could be under certain worst case conditions. Therefore an analysis was performed to provide an estimate of the worst-case interference caused by LMDS CPE main beam interaction with the main beam of the Iridium satellite.

Overview

The computer model was exercised over many different geometries with different initial conditions. Although the results indicate that the expected interference from LMDS CPEs into the Iridium satellites is low, concern has been expressed that the model may not provide information about the interference under certain worst-case geometries and CPE operations. Therefore a separate model was developed to analyze the interference into the Iridium satellite by CPE transmitters when the parameters are adjusted for worst-case conditions. This model does not provide any estimate of the probability of this result, but only establishes an upper bound on the interference based on the worst-case conditions for direct main beam interaction.

The first step is to define the worst case scenario. Although a "worst-case" could be defined for all CPE antennas coupling into the Iridium satellite, this would be completely unrealistic because of the CPE distributions. Therefore we should define the worst-case scenario as one which is realistic, although highly improbable. The worst-case scenario will be defined based on the design parameters of the different LMDS systems and the expected deployment scenario. The analysis will be performed for the various LMDS system implementations and for two satellite footprints. The worst-case earth-satellite geometry is assumed to be one which places the satellite antenna 2.5 degrees above the horizon. All CPE antennas are assumed to be pointed at the horizon. Therefore the Iridium satellite "sees" all CPE antennas pointed in the direction of the satellite. Although the CPE antenna-satellite distance varies over the satellite footprint, this distance is assumed to be equal to the distance between the Iridium gateway and the satellite in each case. The analysis calculates the total LMDS CPE power spectral area density in the satellite footprint for this worst-case scenario and shows a range of -30.2 to -46.65 dBW/MHz-km^2 for the large satellite footprint.

System Parameters

There may be numerous LMDS system implementations. Therefore the analysis was performed for four typical LMDS system implementations which represent a broad range of system parameters and distribution geometries. The analysis was also performed for different system operating parameters. The LMDS system parameters used in the analyses are shown in Table Five. The satellite parameters are shown in Table Six. The parameters are based on maximum capacity and assume the full 150 MHz return bandwidth is utilized. The satellite elevation angle and subscriber antenna elevation angles are adjusted to provide maximum interference on the horizon..

Table Five: Direct Beam LMDS System Parameters

System Parameter	(TI) Sys 1	(CV) Sys 2	(HP) Sys 3	(EG) Sys 4
1. Number of Subscriber Channels in 150 MHz BW	60	150	150	6
2. Number of Subscribers per Node in 150 MHz BW	5760	14400	3600	120
3. Subscriber Distribution	------------Uniform-------------			
4. Subscriber Duty Cycle, %	4	4	4	100
5. Subscriber Antenna Elevation Angle, degrees	2.5	2.5	2.5	2.5
6. Subscriber Antenna Gain, dB	34	31	35	39
7. Antenna 3 dB Beamwidth, degrees	2.5	4.0	3.0	2.5
8. Subscriber TX bandwidth, MHz	2.5	1.0	1.0	24
9. Subscriber TX Power, Clear Air, dBW	-17	-23	-19.6	-13
10. Hub Density (Actual No. Hubs/Maximum No. Hubs)				
a. In 200 km X 400 km footprint	0.25	0.25	0.25	0.25
b. In 2000 km X 400 km footprint	0.1	0.1	0.1	0.1
11. Cell (hub) spacing, km	5	5	2	2.2

Table Six: Direct Beam Satellite Parameters

1. Satellite Footprint	
a. Small	200 km X 400 km
b. Large	2000 km X 400 km
2. Allowed Power Spectral Density	- 26 dBW/MHz-km^2
3. Receiver Bandwidth	6.25 MHz
4. Satellite Elevation angle, degrees	2.5

In addition to these parameters, a number of assumptions about the system were used in the calculations. These assumptions are:

Percent of CPE signals having same polarization as satellite	50%
Percent of CPEs having clear LOS path to satellite	50%
Percent of CPEs simultaneously active	50%

Direct Beam Interaction Analysis Results

The system parameters for the four systems were used to analyze the expected interference level radiated from within the satellite footprint. Two footprints were used: 200 X 400 km and 2000 X 400 km. The total interference was calculated in terms of dBW/MHz-km^2. The analysis procedure and equations are described in the following paragraphs and summarized at the end.

The first step is to calculate the Effective Isotropic Radiated Power (EIRP) from any CPE. This is calculated as follows

$$P_{EIRP} = P_{TX} + G_{TX\ ANT}$$

The EIRP Power Spectral Density is then calculated, based on the channel bandwidth for the particular system:

$$PSD_{EIRP} = P_{EIRP} - 10 \log (BW)$$

Since Adaptive Power Control is used at each CPE to normalize the received power at the node or hub antenna, the average power of the CPE transmitter can be used. The average power is taken to be the power averaged over all CPE transmitters associated with a hub. Since the CPEs are uniformly distributed in area about the hub, the average power is the power radiated by a CPE located on the boundary of a circle which equally divides the